CONTROL OF GANTRY CRANE SYSTEM BASED ON FUZZY LOGIC TECHNIQUE

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To my beloved family, lecturers and friends who have given me a lot of support and encouragement. Thank you so much.

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ABSTRACT

Gantry cranes are widely used in industry for transporting heavy loads and hazardous materials in shipyards, factories, nuclear installations, and high building construction. The crane should move the load as fast as possible without causing any excessive movement at the final position. However, most of the common gantry crane results in a swing motion when payload is suddenly stopped after a fast motion. The swing motion can be reduced but will be time consuming i.e. reduce the facility availability as well as productivity. Moreover, the gantry crane needs a skilful operator to control manually based on his or her experiences to stop the swing immediately at the right position. Furthermore to unload, the operator has to wait the load stop from swinging. The failure of controlling crane also might cause accident and may harm people and surrounding. To overcome this problem, an intelligent gantry crane system had been introduced. Fuzzy logic controllers is proposed, designed and implemented for controlling payload position as well as the swing angle of the gantry crane. PID control approach will be taken as comparator based on the previous research. This project is to propose the control design of AC Servo drive system for linear guide application of gantry crane. The typical linear guide applications can be hoist system like crane, lift, gantry crane system. In this proposed control design, the main purpose of controlling gantry crane system is transporting the load as fast as possible to the required position with precision, without any force disturbance and parameter variations which is swing motion which cause a steady and/or transient error in the conventional ac servo drive system. Basically this system is designed according to the experimental results which convinced the collected data obtained, and simulation approach.

ABSTRAK

Kren gantri digunakan secara meluas dalam industri untuk mengangkut beban berat dan bahan-bahan berbahaya di limbungan kapal, kilang, pepasangan nuklear, dan pembinaan bangunan tinggi. Kren harus bergerak secepat mungkin tanpa menyebabkan mana-mana pergerakan yang berlebihan di kedudukan terakhir. Walau bagaimanapun, yang paling biasa kren gantri bermasaalah dalam gerakan ayunan apabila muatan tiba-tiba dihentikan selepas gerakan pantas. Sudut ayunan boleh dikurangkan tetapi akan memakan masa iaitu mengurangkan adanya kemudahan serta produktiviti. Selain itu, kren gantri memerlukan pengendali mahir untuk mengawal secara manual berdasarkan pengalaman beliau untuk menghentikan ayunan segera di kedudukan yang betul. Tambahan pula untuk memunggah, pengendali telah menunggu hentian beban dari buaian. Kegagalan mengawal kren juga mungkin menyebabkan kemalangan dan boleh membahayakan orang dan sekitarnya. Untuk mengatasi masalah ini, pintar gantri kren sistem telah diperkenalkan. Fuzzy logik adalah dicadangkan, direka dan dilaksanakan untuk mengawal kedudukan muatan serta sudut swing kren gantri. Pendekatan kawalan PID akan diambil sebagai comparator berdasarkan penyelidikan sebelumnya. Projek ini adalah untuk mencadangkan reka bentuk kawalan AC sistem pemacu servo untuk aplikasi panduan linear gantri kren. Panduan tipikal aplikasi linear boleh angkat sistem seperti kren, lif, sistem gantri kren. Dalam reka bentuk kawalan yang dicadangkan ini, tujuan utama sistem kren gantri mengawal dan mengangkut beban secepat mungkin pada kedudukan yang dikehendaki dengan tepat, tanpa gangguan mana-mana angkatan dan variasi parameter yang merupakan gerakan ayunan yang menyebabkan kesilapan yang mantap dan / atau fana dalam ac konvensional servo drive sistem. Pada asasnya, sistem ini direka mengikut kepada keputusan eksperimen yang membuktikan data yang dikumpul diperolehi, dan pendekatan simulasi.

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LIST OF ABBREVIATIONS

PLC	-	Programmable Logic Controller
FLC	-	Fuzzy Logic Controller
FB	-	Function Block
PID	-	Proportional-Integrator-Derivative
PD	-	Proportional-Derivative
AC	-	Alternate Current
VRML	-	Virtual Reality Modeling Language

LIST OF SYMBOLS

b	-	Exponention friction factor
b_m	-	Motor damping coefficient
D	-	Viscose friction coefficient
F_c	-	Coulomb friction coefficient
F_s	-	Maximal static friction
J_1	-	Load inertia
J_m	-	Motor inertia
i_{amax}	-	Maximal amplifier current
K	-	Motor gain
K_s	-	Gear stiffness factor
L_a	-	Inductance of magnetizing circuit
n	-	Gear transmission
R_a	-	Resistance of magnetizing circuit
T_{fm}	-	Motor starting torque backlash

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This project is basically designing and implementing fuzzy logic control to control payload position as well as the swing angle for an intelligent gantry crane system. Throughout the world, there have been many researches about the concept and implementation of this system which is deemed suitable for all types of control applications. For this project, the implementation of fuzzy logic control is applied to a gantry crane model to overcome and improve the performance level from other controllers approach proposed such as PD and PID, which is been said that they have higher steady state error and low sensitivity to disturbance. The fuzzy logic controllers were designed based on information of the skillful operators and without the need of crane model and its parameters [5]. The performance of the proposed intelligent gantry crane system had been evaluated based on simulation and experimentally on a lab-scale gantry crane system.

In this project, AC Servo drive system is been introduced to control the linear guide which is application of gantry crane. When people talk about servo drives today, they generally mean highly dynamic three-phase drives. Servo drives primarily perform positioning tasks in tooling machines, manipulators or robots. But these ac servo drive system are increasingly finding their way into printing machines, conveyor belts and cutting machinery where precise positioning or angular synchronism are required. Here, servo converters, motors with sensor technology and mechanical transfer elements form an extremely integrated system whose components have to be seen as a single entity. Because of the low cost, high reliability, power efficiency, and easy maintenance, induction and permanent-magnet AC motor drives have been widely used in industrial applications, which stimulate research in its motion control to achieve high performance.

The development of fuzzy logic control design is implemented using fuzzy logic toolbox in Matlab Simulink. The main features of the fuzzy logic design process consist of the development of input and output of the membership functions. In the case of gantry crane, error and error rate of position and swing angle are taken into consideration as an input. Meanwhile, the voltage is taken as an output. Since there is no specific form to be used when designing fuzzy logic control, thus, the basic triangle and trapezoidal forms are chosen for input and output membership functions [17]. In most cases, the performance of fuzzy control is minimally influenced by the shapes of memberships, but mainly by the characteristics of control rules.

As for the hardware part, it consists of many parts of mechanical sub-system, an actuation mechanism for transferring payload, position and swing angle sensors, real-time control software/hardware. PLC S7-300 (Siemens) model is used as controller mechanism to control AC Servo drive system which attached to the linear guide for positioning of gantry crane in with the payload is connected. Two sensors are used to measure linear guide position and payload swing angle. For this lab scale gantry crane, a planar movement with fixed cable, length of cable and fixed load is been considered. The experiment will be run based on the fuzzy controlled parameters setting.

1.2 Objectives

The main objective of this project is to design and implement fuzzy logic control in order to control payload position as well as the swing angle for an intelligent gantry crane system. The objectives can be narrowed to many intentions :

(i) To design the control algorithm for planar gantry crane system by using fuzzy logic controllers to control the payload position to be moved to the desired position while payload swing angle will be kept asymptotically small at final position.

(ii) To develop simulation for the proposed system.

(iii) To implement the proposed control method based on the VRML animation and lab scale gantry crane design based on experimental and compare the result effectiveness with classical PID controllers approach.

1.3 Scope of Project

This project is a combination of hardware and software parts development to implement the fuzzy logic control method on gantry crane system. For the software part, MATLAB Simulink software is chosen to program and simulate the fuzzy logic controller and apply to the gantry crane system.

The scopes of project for software are :

i. Literature study on the most appropriate programming and toolbox in Matlab Simulink for simulation of proposed gantry crane model.
ii. Analyze and study on how to design a fuzzy logic controller.

iii. Apply fuzzy logic controller algorithm to the developed model of gantry crane in Matlab Simulink.

iv. Run the simulation and design in VRML animation and fix the error.

v. Interface the software and hardware part by using Simatic Net Software to communicate FuzzyControl++ and Programmable Logic Controller (PLC) from Siemens. The programming for the PLC is been done using Simatic S7 PLC (SIEMENS).

1.4 Methodology

In order to meet the objectives of the project, the system is designed based on several steps of approach which to optimize the anti-swing and zero steady state error performance of gantry crane system. The methodology to complete this project will be done on simulation and experiment evaluation. The control method proposed is Fuzzy logic control (FLC). Fuzzy logic controller will be compared with PID controller from previous researches, which the existing mathematical model development will be applied for ac servo and gantry crane. The proposed FLC is based on fuzzy algorithm and the fuzzy rules developed.

The proposed controller consists of fuzzy logic controllers for both position and anti-swing control respectively. The objective of the proposed fuzzy logic controllers is to control the payload position X(s) so that it moves to the desired position Xref(s) as fast as possible without excessive swing angle of the payload θ(s). Here, the design of fuzzy logic control is based on a heuristic approach. Figure 1.1 below shows the flow chart of project methodology.

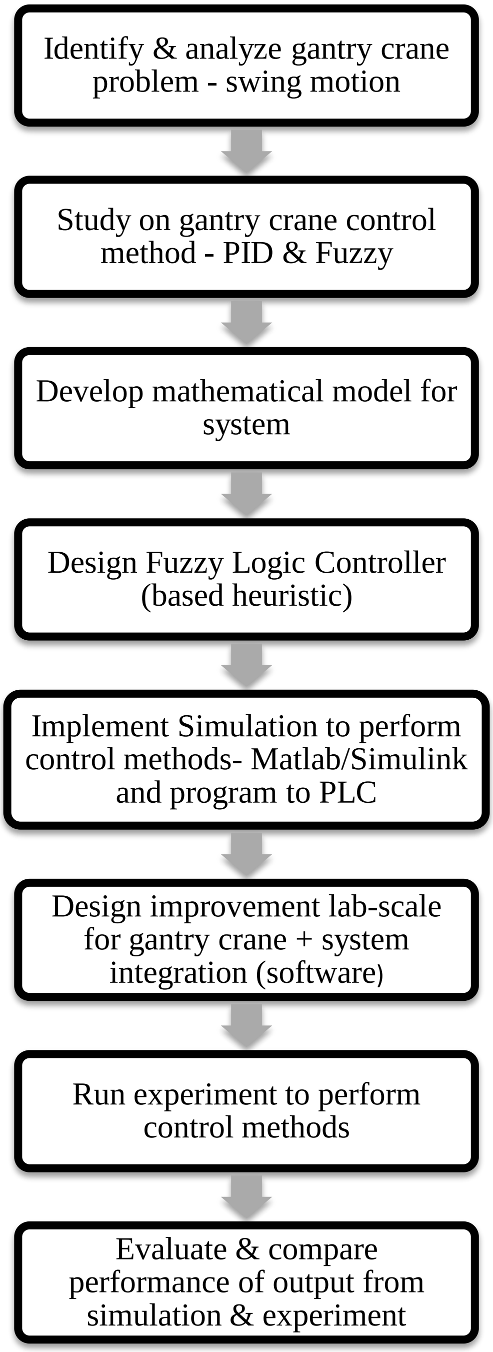

Figure 1.1 : Flow Chart of Project Methodology

1.5 Thesis Outline

This thesis consists of six chapters. Chapter 1 is about the introduction, objectives, scope of project and methodology. The purpose is to give a brief overview of this project.

Chapter 2 defines and illustrates the steps employed in the fuzzy logic controller. Including detailed about modeling and derivation of equations for the gantry crane system. All these methodology should be followed for a better performance.

Chapter 3 is the fuzzy logic controller. This chapter provides a theory of fuzzy logic, the fuzzy logic control system, fuzzy logic control design and application of fuzzy control to a gantry crane. It describes about research and information about the project, which every fact found through the journals or other references, will be compared and the better methods have been chosen for the project.

Chapter 4 shows the details of designing a controller and dynamic system in simulation Matlab/Simulink and VRML animation. It also describes the analysis of project findings. The results are presented by the transient response of the output performance.

Chapter 5 describes about the implementation of experimental on lab-scale of gantry crane in terms of software and hardware parts.

Chapter 6 provides the conclusion and some suggestion for future works for this project.

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